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Quality Assessment Of Drinking Water Provided At Different Housing Schemes In Visakhapatnam: A Case Study

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Abstract

Purpose: To investigate the chemical and physical aspects of Vizag's water quality in a few key regions.

Materials and Method: In order to conduct the study, water samples were taken from the Vishakhapatnam neighbourhoods A, B, C, and D, and sent to Spectra Environment Tech Pvt Ltd for analysis.

Result: The World Health Organisation standard for drinking water (WHO) and BIS standard were found to be met by the drinking water of the chosen study area from Vishakhapatnam in all physico-chemical parameters in all 4 areas, namely A, B, C, and D drinking water sampling sites. The samples were examined using widely renowned and well-established analytical procedures for the intended water quality indicators. It is clear that all of the chosen parameters were deemed to be within the organization's standards.

Conclusion: Conclusion: The water quality in the chosen sites is suitable for human consumption.

Dissemination of the water quality status in government reports via social media, print media, and television can increase public satisfaction.

Keywords: Water quality, Vishakhapatnam, Chemical parameters, physical parameters, WHO, BIS.

Introduction

Water is a vital resource for human life, according to Wuvitch et al.'s research from 2020. The usage of freshwater worldwide has increased by a factor of six over the previous century and has been expanding at a rate of roughly one percent per year since the 1980s, according to the UNESCO-published 2021 World Water Development Report. Source: Lin et al., (2022). All living organisms on Earth need water and oxygen in order to survive. These two elements are also vital for life to exist. All nations have a responsibility to work towards reaching the goal of ensuring that everyone has access to clean water to drink, sanitation facilities, and good hygiene practises in their homes, according to the World Health Organisation (2009). Every person is entitled to the fundamental human right to obtain safe drinking water, regardless of their nationality, religion, or race, as well as their wealth or creed. According to the World Health Organisation (2018), inadequate sanitation and tainted drinking water are to blame for the development of diseases like cholera, diarrhoea, dysentery, and polio. Because of the low quality of the drinking water, the customers are directly suffering grave health consequences. At least 2 billion people in the globe acquire their drinking water from a source that is contaminated with faeces, according to UNICEF (2016).

The quality of the available water is under severe stress as a result of increased levels of water demand. Environmental deterioration and contamination have been facilitated by industrialization, agricultural production, and urban living. This has had a detrimental effect on the life-supporting water bodies (rivers and oceans), which has affected human health and long-term societal development (Xu et al., 2022). According to estimates, 80% of wastewater from commercial and municipal sources is discharged into the environment without any type of treatment, which can have detrimental effects on both human health and the health of ecosystems. This proportion is considerably higher in the world's least developed nations, which have a serious lack of sanitation and wastewater treatment facilities, according to Xiao et al. (2019).

Understanding the existing drinking water quality and the associated health concerns is the first step in being able to make informed decisions about the management and protection of drinking water quality. Su et al. (2019) claim that in order to get accurate results and make wise decisions, it is crucial to employ a realistic and effective drinking water quality evaluation approach. Water scarcity that can be used for drinking is one of India's biggest issues. More than 44 million people in India contracted viral hepatitis and enteric fever between 2014 and 2016 as a result of drinking contaminated water (WELFARE 2017). The spread of illnesses that make drinking water unsafe can be stopped by ensuring that everyone has access to enough levels of energy (Deshmukh et al. 2014). According to the National Portal of the Government of India (2020), India has a total land area of 3,287,263 km2, making it the seventh largest country in the world. Understanding the existing drinking water quality and the related health concerns is the first step in making informed decisions about the management and protection of drinking water quality in India. In order to get reliable results and facilitate making wise decisions, it is crucial to employ a practical and effective method of evaluating the quality of drinking water. One of the districts along Andhra Pradesh's north coast is the Visakhapatnam district. The semi-enclosed body of water known as Visakhapatnam Harbour, which is situated on India's east coast, is highly polluted due to waste products from both industrial and urban sources. (1995; Raman and Chang)

Given the aforementioned setting, the current study's goal is to look into the water quality in a few different areas of Visakhapatnam.

Objectives

The current study is been made with the following objectives,

1. To study the physical and chemical parameters (pH, acidity, alkalinity, chlorine, hardness, dissolved oxygen, and biological oxygen demand, color, taste, odor, temperature, turbidity, solids, and electrical conductivity) of drinking water in selected residential area
2. To identify the presence of any toxic substance in the water supplied to the selected housing schemes
3. To compare and assess area / scheme that supplies optimal quality drinking water

Methodology

The current study project is being conducted in the city of Vishakhapatnam. The city of Visakhapatnam, which is located on the eastern coast of India at 17 degrees 42 minutes north latitude and 82 degrees 02 minutes east longitude, has a total area of more than 600 square kilometres. It is included among the top 100 cities in the world with the highest population increase and is the second-largest metropolis in the state of Andhra Pradesh. It was ranked as the fifth cleanest city in India overall by the Swachhta Sarvekshan rankings developed by the Indian government. The average literacy rate in the city is 82.6%, which is much higher than the 59.5% national average. Men are more likely than women to be literate (88% versus 77.1%). When water cannot be used for the intended purpose, it is said to be contaminated. Both the quantity and the quality of the available ground water are essential. A population must have access to a source of drinkable water that is both sufficient in quantity and of sufficient quality if they are to survive. The water samples were collected at four distinct sites throughout Vizag. places where water samples were taken overall, including those in urban and industrial areas. The results of the current investigation's analysis of various physical and chemical parameters of water samples were compared to values of various water quality standards, including those created by the World Health Organisation (WHO), the Bureau of Indian Standards (BIS), and the Central Public Health and Environmental Engineering Organisation (CPHEEO). Important physical and chemical parameters, such as pH, EC, TDS, THD, Ca, Mg, Na, K, Cl, etc., were measured using established techniques and evaluated using the samples that were collected. Utilising the samples that were gathered by Spectra Environment Tech Pvt Ltd, these parameters were examined. All of the chemical components are listed in milligrammes per litre (mg/L), with the exception of pH and EC.

Findings of the study

In order to have a better understanding of the water quality in certain parts of Vishakhapatnam, a research was designed. In the first step of this investigation, the investigator made an effort to comprehend the physical parameters of drinking water as well as the chemical parameters of the drinking water from the places that were chosen. The pH result of the water was found to be within the standard value for areas B and C, but the pH value was found to be a bit lower when compared to the standard value for areas A and D. The standard value was determined to be 7. The colour of the water in the areas that were chosen for examination had their colour measured, and the results showed that the standard value was 5, while all of the places had their colour measured to be lower than 5, showing that the colour of the water was satisfactory. The colour of the water was judged to be an average of 0.63 across the selected places, with a standard deviation value of 0.56. This suggests that the colour of the water was very consistent throughout the selected areas.

Turbidity parameters of the water were estimated within the standard value range of 1 to 5 NTU. It was discovered that all of the selected areas had higher turbidity ratios, and the average algae turbidity in the drinking water of the selected areas was 10.32, indicating that the water contains chemical and biological particles. It was discovered that area A had a turbidity level of 11.4 NTU, which is considered to be high, whereas area B had a turbidity level of 9.07, which is considered to be low. The standard value was set at 500, and all of the places had values that were lower than this range. The average value was 152.50, and the standard deviation rate was 59.29. This information on the total dissolved solids in the drinking water was found for all of the 4 selected areas. The standard value was set at 500, and all of the regions had values that were lower than this range.

Electrical conductivity of the selected regions showed that all of areas A, B, C, and D had conductivity values that were greater than 7, with their average value being estimated to be 7.24 and their standard deviation value being 0.18. This was determined by measuring the electrical conductivity in these places.

Pure water acts more like an insulator than a conductor of electricity because of its lack of impurities. An increase in the water's concentration of ions results in an increase in the liquid's ability to conduct electricity. In most cases, the electrical conductivity of water is determined by the total amount of dissolved solids present in that water. The electrical conductivity (EC) of a solution is, in reality, a measurement of the ionic mechanism that permits the solution to transmit current. According to the most recent analysis, the EC value ranged from 7.01 to 7.45, with a value of 7.24 serving as the average. These findings make it abundantly evident that the water in the area under investigation was not significantly ionised and possesses a lower degree of ionic concentration activity as a consequence of the presence of tiny dissolved particles.

The total hardness of the study area as measured in CaCo3 was analysed, and the results revealed that the standard value should have been set at 300, but the values actually ranged from 36 to 132, with the average coming in at 132. The value that was found to be most common was 132.

In the course of the research, the alkalinity of the water in the designated locations was evaluated. According to the recommendations, the alkalinity of water should be 200, however the alkalinity that was found in the area under research ranged from 6.73 to 11.8, with 9.60 being the average amount of alkalinity present.

Ingestion of drinking water with concentrations of chlorine up to 4 milligrammes per litre (mg/L or 4 parts per million (ppm)) is not thought to pose any health risks. At this concentration, there is a low probability that adverse consequences on health may occur. In the current investigation, the levels of chloride were predicted to fall anywhere between 9.99 and 45.98, with 23.49 being the number that represented the mean.

The water quality of the places that were chosen for comparison was compared to both the WHO standard and the BIS standard. The fact that the majority of the parameters satisfied the requirements established by WHO and BIS was interpreted as evidence that the water's quality was satisfactory.

Discussion

Every living being on earth requires water in order to survive, and scientific research has shown that water contains an extraordinarily diverse array of minerals. In the case of drinking water, each and every human being is required to have access to high-quality drinking water, the pH of which indicates how acidic or basic the water is. The range is from 0 to 14, with 7 representing the middle ground. A pH reading lower than 7 denotes acidity, whereas a pH reading higher than 7 indicates the presence of a base. In reality, pH is just a measurement of the proportion of free hydrogen ions to hydroxyl ions that are present in the water. In the current research, the pH value measurements revealed that the standard value range lies between 6.5 and 8.5. Area A had a pH value of 6.28, which is slightly lower than the standard value, whereas area D had a pH value of 6.09, which is somewhat higher than the standard value. All of the other locations had pH values that fell within the specified standard ranges. This suggested that locations A and D might have naturally somewhat acidic water, whereas the drinking water in the other areas is considered to be normal. This was very similar to the findings that were produced by Su et al. (2019), in which it was mentioned that acidic water has an effect on the health of humans.

The clarity and cleanliness of drinking water is something that is taken for granted; when water takes on colours like brown, yellow, or red, customers are likely to get concerned and lodge complaints. Particles that are floating in the water and those that are dissolved in the water can either absorb or reflect light, and the result is the appearance of colour in the water. The more particles there are, the more colour there is in the water.1 The most significant contributors to the colour of water are iron complexes, humic and organic components, and the action of bacteria on dissolved manganese particles. In most cases, the colour of water does not present a health danger to consumers; however, people are less likely to drink water that has a cloudy appearance because they perceive it to be unclean. In the places that were chosen, the colour of the water was within the specified range, which indicates that the areas were serviced by a quality water supply that was free of any discoloration.

In drinking-water sources, turbidity, which is caused by chemical and biological particles that are suspended in the water, can have repercussions for both the aesthetics and the safety of the water. rather, turbidity can indicate the presence of pathogenic bacteria and can be an efficient signal of hazardous events across the water supply system, from the catchment to the point of use. Turbidity does not always constitute a direct risk to public health; rather, it can indicate the presence of pathogenic microorganisms. An increase in turbidity in distribution systems can indicate sloughing of biofilms and oxide scales or ingress of contaminants through faults such as mains breaks. High turbidity in filtered water can indicate poor removal of pathogens. For example, high turbidity in source waters can harbour microbial pathogens, which can be attached to particles and impair disinfection. In the places that were chosen, the turbidity value was greater than the standard value, which suggests that there may be chemical particles and biological particles present in the water.

The amount of organic and inorganic elements, including as metals, minerals, salts, and ions, that are dissolved in a specific volume of water is referred to as the total dissolved solids (TDS). Total dissolved solids are essentially a measurement of anything that is dissolved in water that is not an H2O molecule. When water comes into contact with a material that is soluble, it acts as a solvent, which means that the particles of the material are dissolved into the water. This results in the creation of total dissolved solids. The total dissolved solids (TDS) in water can originate from virtually any source, such as natural water springs, the chemicals used to clean the municipal water supply, runoff from roads and yards, and even the plumbing system in your own home. The total dissolved solids can originate from a wide variety of natural and artificial sources. TDS can come from a variety of natural sources, such as springs, lakes, rivers, plants, and soil. For instance, when water flows underground in a natural spring, it collects minerals from rocks, such as calcium, magnesium, and potassium. These minerals are found in relatively high concentrations in the water. On the other hand, total dissolved solids in water can be produced as a result of the consequences of human activity. It's possible that agricultural runoff contains pesticides and herbicides; lead and chlorine could flow from older plumbing pipes; and chlorine could originate from water treatment plants. The maximum quantity of TDS that should be present in your drinking water is indicated to be 500 ppm. Any reading of TDS that is more than 1000 ppm is considered a dangerous level. If the concentration is more than 2000 ppm, the filtration system might not be able to remove all of the TDS effectively. In the locations that were studied, it was discovered that the TDS value was lower than 500, which indicates that the drinking water is of a high quality; this conclusion was comparable to the one made by Lin et al., (2022).

The presence of dissolved minerals containing Ca2+, Mg2+, Al3+, Iron, and other heavy metals is the primary cause of hardness in water. Specifically as a result of Magnesium Sulphate, Magnesium Bicarbonate, and Magnesium chloride, as well as Calcum Sulphate, Calcium Bicarbonate, and Calcium chloride. Another definition for it is the amount of soap that can be consumed by a given volume of water. When the range of caco3 is between 0 and 60, then the water is regarded to be soft. When the range of caco3 is between 60 and 120, then the water is considered to be moderately hard water. When the range of caco3 is between 120 and 180, then the water is considered to be hard. When the range of caco3 is beyond 180, then the water is considered to be very hard. The location that was being investigated for this particular research project had water with an average hardness of 132, which places it in the category of having hard water. In most contexts, the term "hard water" refers to water that has a relatively high proportion of dissolved calcium and magnesium ions. The vast majority of people are able to consume either hard or soft water without any adverse consequences. Some individuals might be concerned about the higher sodium levels that come with soft water, but this problem can be solved with a water softening system that uses potassium.

The presence of bicarbonate, carbonate, or hydroxide components can be used to determine the alkalinity of a solution. For residential water supply, concentrations of fewer than 100 parts per million are preferable. The range of 30 to 400 ppm is the one that is suggested for drinking water. The current investigation found that the alkalinity content was extremely low, which is below the limit that is suggested. It is possible that water with a low alkalinity is more susceptible to the chemical corrosion of piping and fixtures. This might lead to a rise in the metal content of the water, which could lead to a condition that could generate an economic issue. This hypothesis was supported by the research conducted by Xu et al., 2022.

According to the findings of the investigation, the amount of chlorine present is more than what is considered normal, which is between 0.2 and 4. The eyes, skin, hair, and teeth are all susceptible to irritation when exposed to chlorine. People who swim frequently are more prone to encounter chlorine's adverse effects, even when swimming occasionally does not generate any substantial negative effects on its own. The respiratory system is susceptible to irritation when exposed to water that contains excessive levels of chlorine as well as built-up chloramines. When exposed to even trace amounts of chlorine, it is possible to have discomfort in the eyes, nose, and throat. At greater concentrations, inhaling chlorine gas can cause alterations in the rate at which a person breathes, as well as coughing and damage to the lungs.

In the form of guidelines, the World Health Organisation (WHO) sets international norms on water quality and human health. These guidelines serve as the basis for regulation and standard setting all around the world. Guidelines for drinking-water quality (GDWQ) promote the protection of public health by advocating for the development of locally relevant standards and regulations (health-based targets), adoption of preventive risk management approaches covering catchment to consumer (Water Safety Plans), and independent surveillance to ensure that Water Safety Plans are being implemented and are effective and that national standards are being met. This protects public health by reducing the likelihood of exposure to contaminants that could be harmful to human health. In the investigation, the majority of the chosen parameters coincided with the WHO standard in terms of their values. IS 10500: 2012 is now considered to be the Indian standard for the quality of drinking water. This standard was produced by the Bureau of Indian Standards (BIS). The Bureau of Indian Standards first released the Indian drinking water standard, also known as the Drinking Water Specification, in the year 1983. The water quality in the areas that were chosen met all of the requirements set forth by BIS. As a result of these findings, it is possible to deduce that the places that were chosen have drinking water that meets acceptable standards.

Conclusion

On the basis of the findings, it was determined that the drinking water in the selected study area from Vishakhapatnam was that all physico–chemical parameters in all of the 4 areas, namely A, B, C and D drinking water sampling sites, and they were consistent with the World Health Organisation standard for drinking water (WHO) and the BIS standard. This conclusion was reached as a result of the fact that all of the areas had drinking water sampling sites. Following analytical procedures that are both well-known and widely accepted on a global scale, the samples were analysed to determine how well they satisfied the specified criteria for water quality. It is plain to see that each of the selected parameters was discovered to fall inside the acceptable range established by the organisation. As a result of this, one can draw the conclusion that the water quality in the chosen places is sufficient and suitable for human consumption. The broadcast of information regarding the status of water quality in government reports across many platforms, including social media, print media, and television, might increase public satisfaction.

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Table 1 Test Results of physical and chemical parameters of drinking water

Test Parameters	Standard Values	Values of selected areas				AVG	SD
		A	B	C	D		
pH	6.5 – 8.5	6.28	7.02	7.50	6.09	6.72	0.66
Color	5	0.2	1.0	1.2	0.1	0.63	0.56
Turbidity	1-5	11.4	9.07	10.4	10.4	10.32	0.96
Total Dissolved Solids	500	214	124	84	188	152.50	59.29
Electrical Conductivity	-	7.01	7.3	7.45	7.20	7.24	0.18
Total Hardness as $CaCO_3$	300	36	36	112	132	79.00	50.32
Alkalinity	200	9.9	6.73	9.9	11.88	9.60	2.13
Chlorides (as CI)	0.2 to 4	9.99	19.99	17.99	45.98	23.49	15.61
Fluorides (as F)	1.0	0.18	0.29	0.20	0.20	0.22	0.05
Sulphate as So_4^{2-}	,250	20.3	25.9	24.2	21.3	22.93	2.58
Residual free Chlorine	0.2	Nil	Nil	Nil	Nil	Nil	0.00
Nitrate as NO_3	45	2.16	2.87	2.35	2.60	2.50	0.31
Magnesium Hardness as $CaCO_3$	30	3.10	3.87	21.17	20.58	12.18	10.05
Iron as Fe	0.30	0.10	0.18	0.14	0.13	0.14	0.03
Calcium as Ca	75	23.24	20.04	24.84	47.29	28.85	12.45

Table 2 Correlation coefficient for physical and chemical parameter of study area

		pH	Color	Turbidity	Total Dissolved Solids	Electrical Conductivity	Total Hardness as CaCO3	Alkalinity	Chlorides (as CI)	Fluorides (as F)	Sulphate as So42-	Nitrate as NO3	Magnesium Hardness as CaCO3	Iron as Fe	Calcium as Ca
pH	Pearson Correlation	1													
	Sig. (2-tailed)														
Color	Pearson Correlation	.987*	1												
	Sig. (2-tailed)	.013													
Turbidity	Pearson Correlation	-.446	-.579	1											
	Sig. (2-tailed)	.554	.421												
TotalDissolved Solids	Pearson Correlation	-.956*	-.959*	.585	1										
	Sig. (2-tailed)	.044	.041	.415											
	Pearson Correlation	.849	.851	-.585	-.964*	1									

Electrical Conductivity	Sig. (2-tailed)	.151	.149	.415	.036										
Total Hardness as CaCO3	Pearson Correlation	-.016	-.080	.098	-.201	.435	1								
	Sig. (2-tailed)	.984	.920	.902	.799	.565									
Alkalinity	Pearson Correlation	-.524	-.627	.674	.424	-.228	.750	1							
	Sig. (2-tailed)	.476	.373	.326	.576	.772	.250								
Chlorides (as Cl)	Pearson Correlation	-.442	-.405	-.198	.160	.097	.739	.558	1						
	Sig. (2-tailed)	.558	.595	.802	.840	.903	.261	.442							
Fluorides (as F)	Pearson Correlation	.368	.514	-.948	-.433	.367	-.405	-.840	-.019	1					
	Sig. (2-tailed)	.632	.486	.052	.567	.633	.595	.160	.981						
Sulphate as So42-	Pearson Correlation	.801	.886	-.889	-.852	.780	-.152	-.766	-.153	.839	1				
	Sig. (2-tailed)	.199	.114	.111	.148	.220	.848	.234	.847	.161					
Nitrate as NO3	Pearson Correlation	.133	.281	-.943	-.322	.380	-.020	-.498	.441	.888	.687	1			

	Sig. (2-tailed)	.867	.719	.057	.678	.620	.980	.502	.559	.112	.313				
Magnesium Hardness as CaCO3	Pearson Correlation	.163	.090	.068	-.358	.565	.982*	.669	.619	-.381	-.040	-.053	1		
	Sig. (2-tailed)	.837	.910	.932	.642	.435	.018	.331	.381	.619	.960	.947			
Iron as Fe	Pearson Correlation	.553	.676	-.992**	-.673	.656	-.106	-.708	.113	.937	.939	.895	-.053	1	
	Sig. (2-tailed)	.447	.324	.008	.327	.344	.894	.292	.887	.063	.061	.105	.947		
Calcium as Ca	Pearson Correlation	-.609	-.621	.171	.377	-.119	.779	.810	.932	-.370	-.483	.095	.647	-.253	1
	Sig. (2-tailed)	.391	.379	.829	.623	.881	.221	.190	.068	.630	.517	.905	.353	.747	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3 Comparing physical and chemical characteristics of analyzed water samples with WHO, BIS and CPHEEO water standards

Chemical Parameters	Observed Concentration				Water Quality Standard		
	Min.	Max.	Mean	Std.Dev	WHO	BIS	CPHEEO
pH	6.09	7.50	6.72	0.66	6.5 – 8.5	6.5 to 8.5	
Color	0.10	1.20	0.63	0.56	No visible Color	5	-
Turbidity	9.07	11.40	10.32	0.96	1 to 5	10	
Total Dissolved Solids	84.00	214.00	152.50	59.29	Below 300	500	500
Electrical Conductivity	7.01	7.45	7.24	0.18	200 to 800	3.27	
Total Hardness as $CaCO_3$	36.00	132.00	79.00	50.32	10 to 500	300 to 500	
Alkalinity	6.73	11.88	9.60	2.13	6.5 to 8.5	7	
Chlorides (as Cl)	9.99	45.98	23.49	15.61	200 to 600	250	
Fluorides (as F)	0.18	0.29	0.22	0.05	1.5 to 2.0	0.6 to 1.2	
Sulphate as So_4^{2-}	20.30	25.90	22.93	2.58	250 to 500	150 to 400	
Residual free Chlorine	2.16	2.87	2.50	0.31	0.2 to 0.5	0.2	
Nitrate as NO_3	3.10	21.17	12.18	10.05	10 to 50	45	
Magnesium Hardness as $CaCO_3$	0.10	0.18	0.14	0.03	50	0.1	
Iron as Fe	20.04	47.29	28.85	12.45	0.3 to 0.6	0.3	
Calcium as Ca	6.09	7.50	6.72	0.66	10 to 300	0.01	